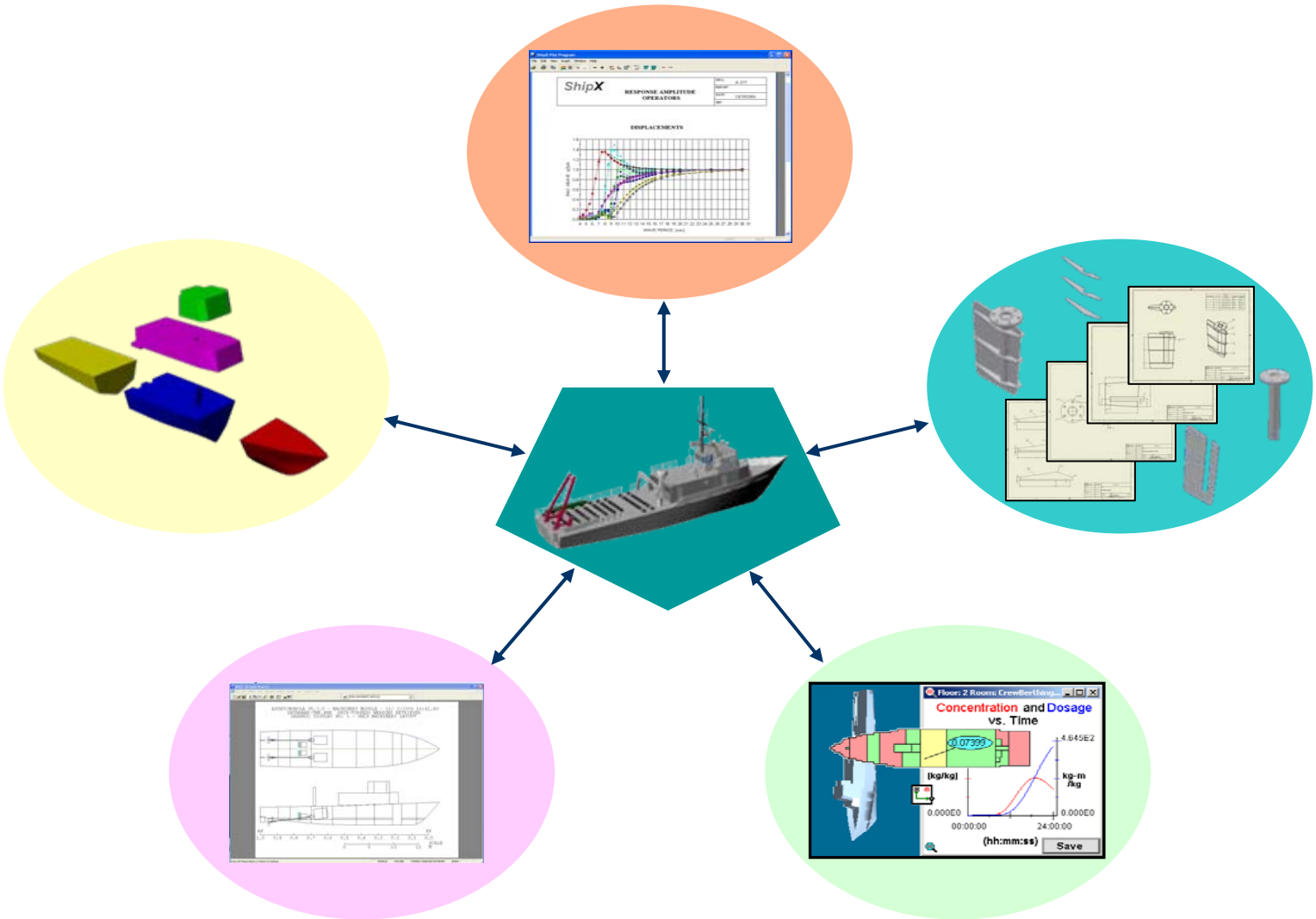
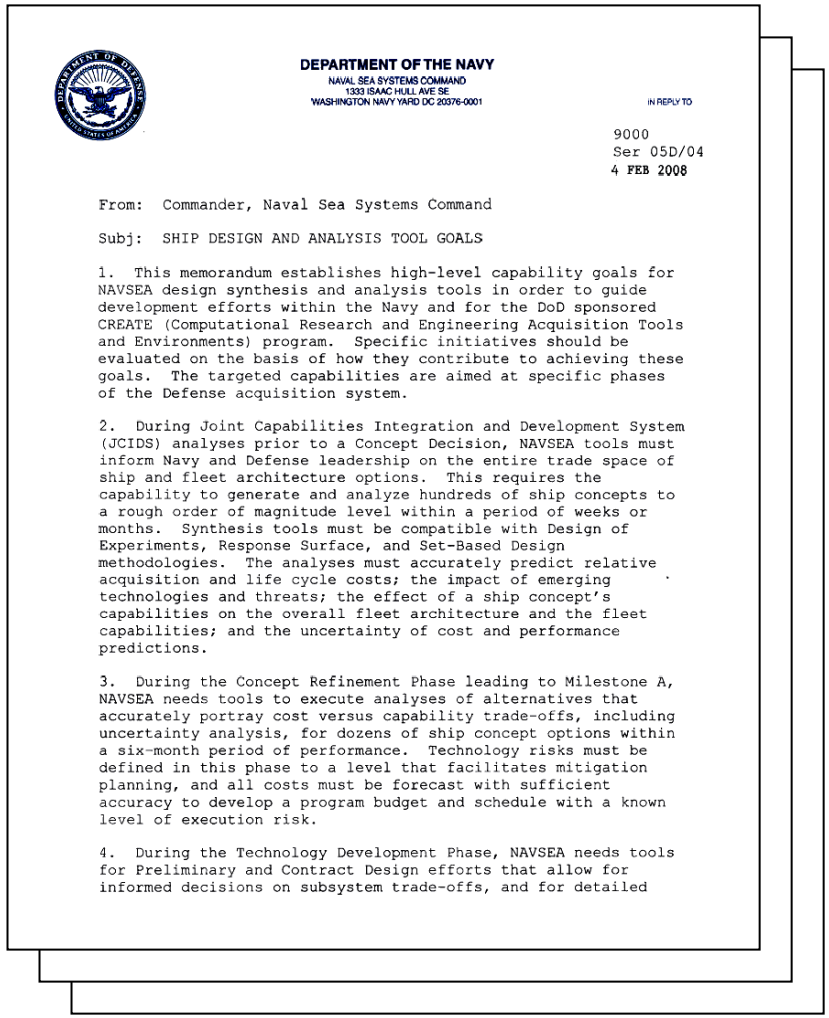
Ship Design Tools: Where are we?



Ship Design and Analysis Tool Goals

- "Accomplishing these ambitious goals will be a challenge, but is essential for crafting affordable, executable ship programs in an increasingly complex national security environment"
  - Still true over a year later
- Requires teaming across Government, Academia, and Industry



DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

IN REPLY TO

9000
Ser 05D/04
4 FEB 2008

From: Commander, Naval Sea Systems Command

Subj: SHIP DESIGN AND ANALYSIS TOOL GOALS

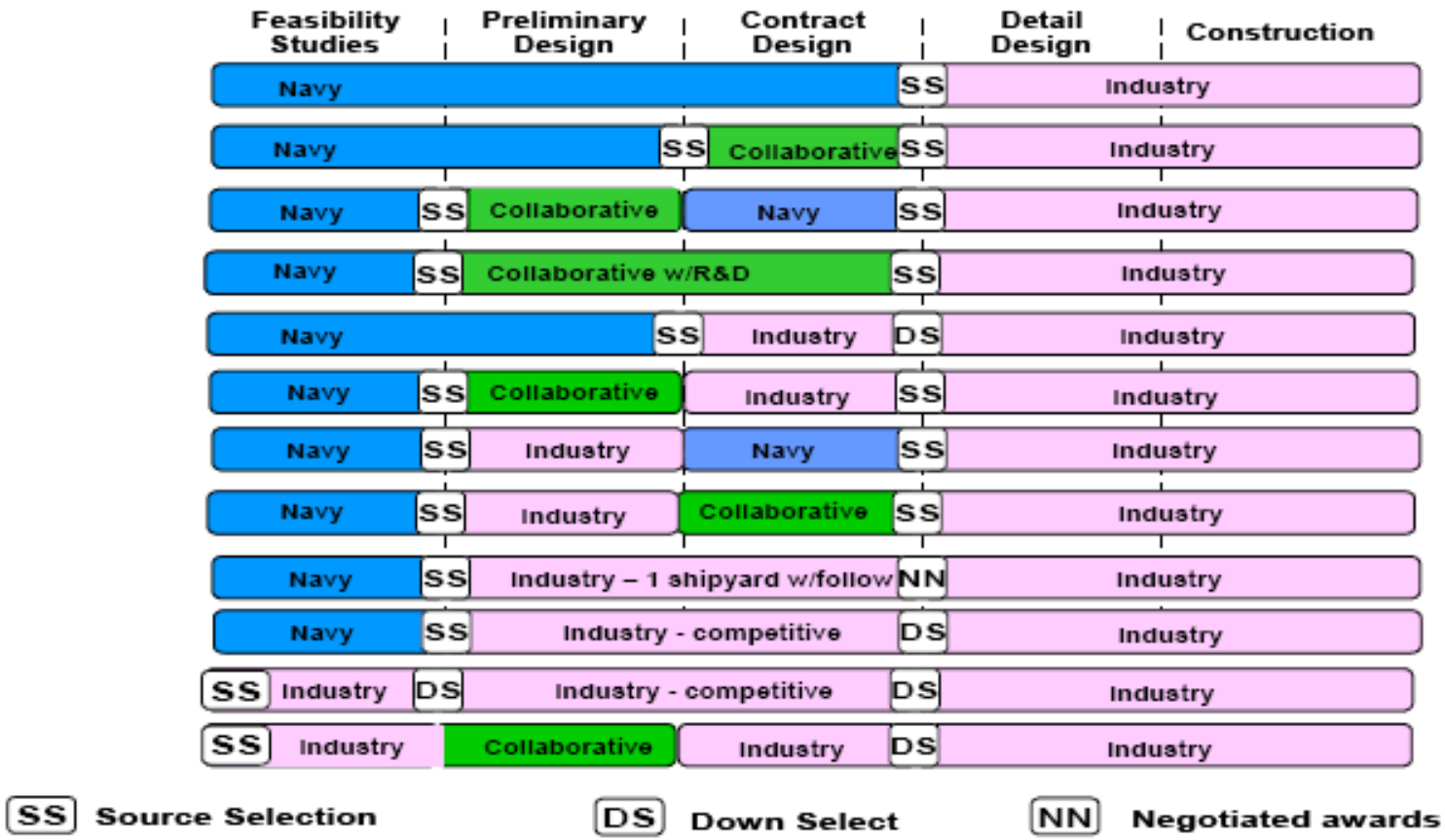
1. This memorandum establishes high-level capability goals for NAVSEA design synthesis and analysis tools in order to guide development efforts within the Navy and for the DoD sponsored CREATE (Computational Research and Engineering Acquisition Tools and Environments) program. Specific initiatives should be evaluated on the basis of how they contribute to achieving these goals. The targeted capabilities are aimed at specific phases of the Defense acquisition system.

2. During Joint Capabilities Integration and Development System (JCIDS) analyses prior to a Concept Decision, NAVSEA tools must inform Navy and Defense leadership on the entire trade space of ship and fleet architecture options. This requires the capability to generate and analyze hundreds of ship concepts to a rough order of magnitude level within a period of weeks or months. Synthesis tools must be compatible with Design of Experiments, Response Surface, and Set-Based Design methodologies. The analyses must accurately predict relative acquisition and life cycle costs; the impact of emerging technologies and threats; the effect of a ship concept's capabilities on the overall fleet architecture and the fleet capabilities; and the uncertainty of cost and performance predictions.

3. During the Concept Refinement Phase leading to Milestone A, NAVSEA needs tools to execute analyses of alternatives that accurately portray cost versus capability trade-offs, including uncertainty analysis, for dozens of ship concept options within a six-month period of performance. Technology risks must be defined in this phase to a level that facilitates mitigation planning, and all costs must be forecast with sufficient accuracy to develop a program budget and schedule with a known level of execution risk.

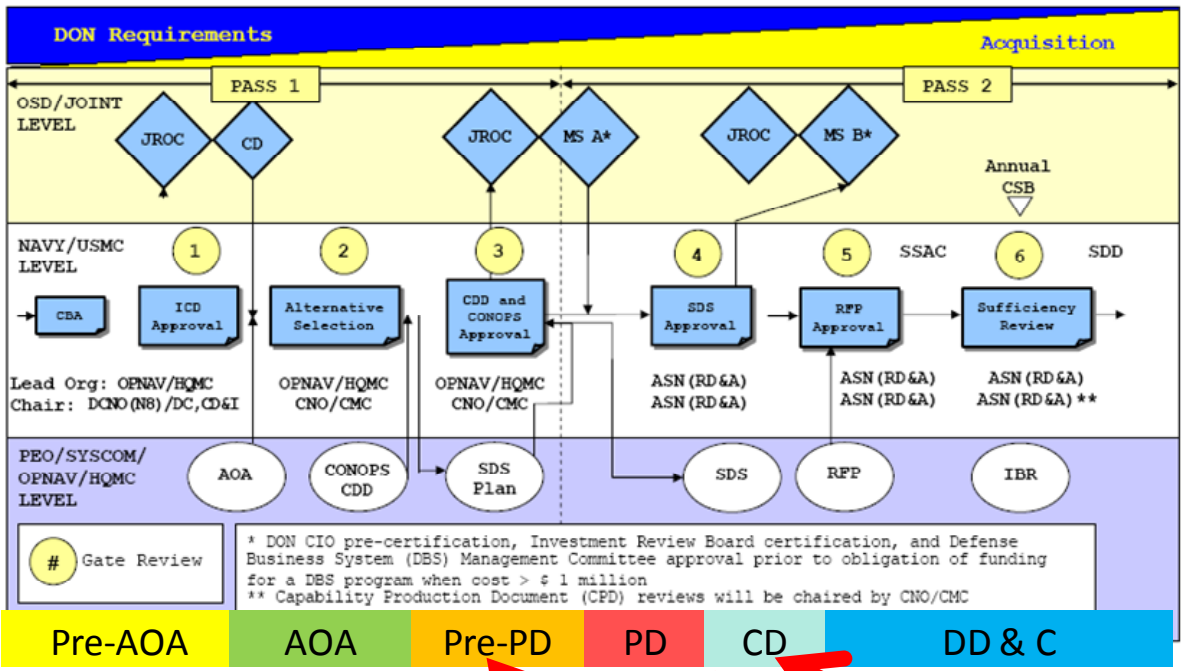
4. During the Technology Development Phase, NAVSEA needs tools for Preliminary and Contract Design efforts that allow for informed decisions on subsystem trade-offs, and for detailed

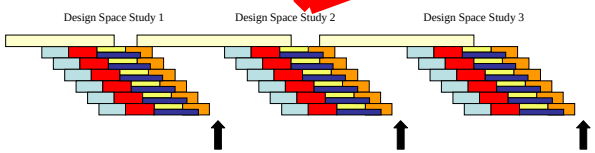
Who does the work?

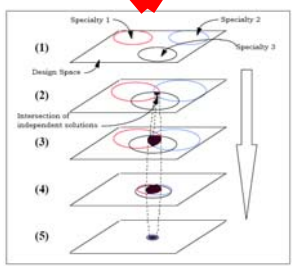


SEA 05 ***must*** have the capability to implement design in all of these acquisition strategies

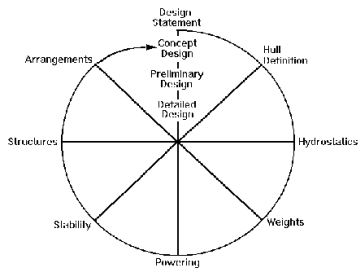
Design Methods and Design Stages







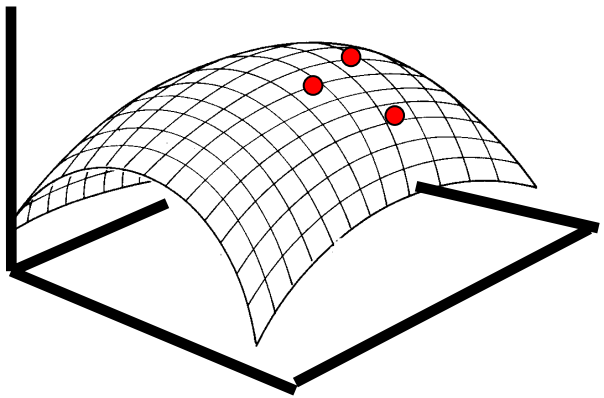
Set Based Design

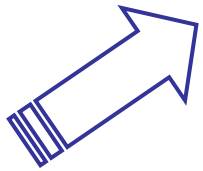


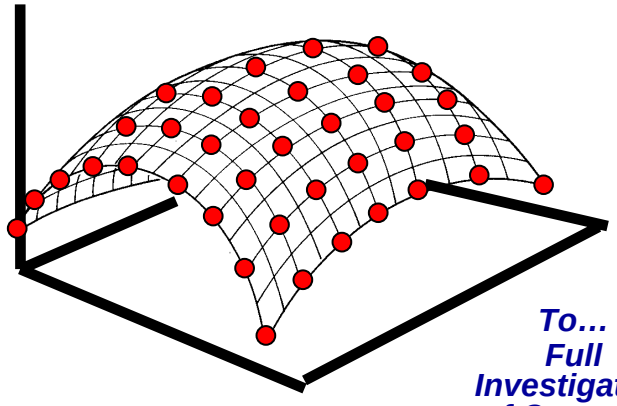
Spiral Design

Design Space Exploration

From…
Limited Investigation of relatively few Design Points



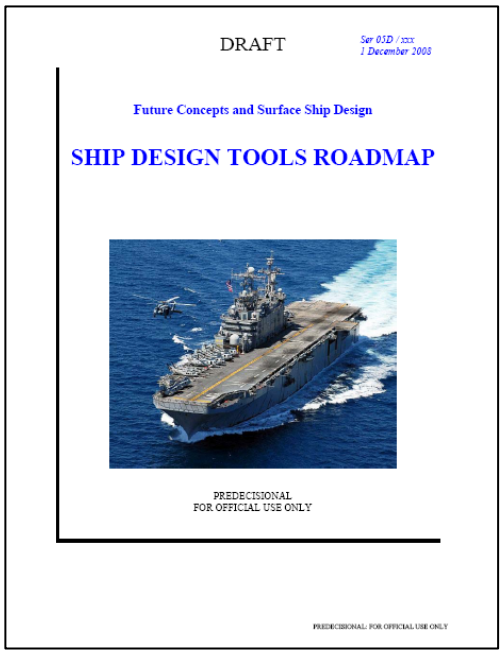




To…
Full Investigation of Concepts throughout the Design Space

- Requires fully automated design synthesis capability
- Goal is multivariate optimization
- Knowledge of tool validation boundaries is critical
- Currently limited to very rough order assessments

Tools Roadmap & Design Process Model


DRAFT

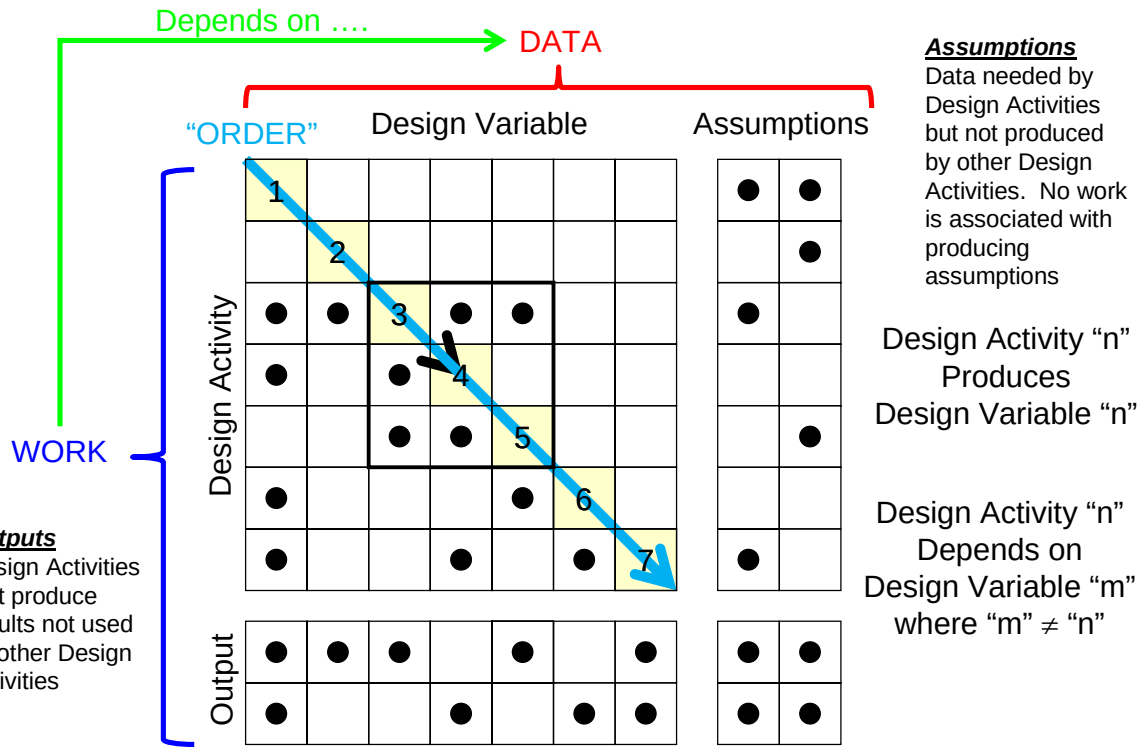
Ser 03D / xxx
1 December 2008

Future Concepts and Surface Ship Design

SHIP DESIGN TOOLS ROADMAP

PREDECISIONAL
FOR OFFICIAL USE ONLY

PREDECISIONAL: FOR OFFICIAL USE ONLY



Assumptions
Data needed by Design Activities but not produced by other Design Activities. No work is associated with producing assumptions

Design Activity "n" Produces Design Variable "n"

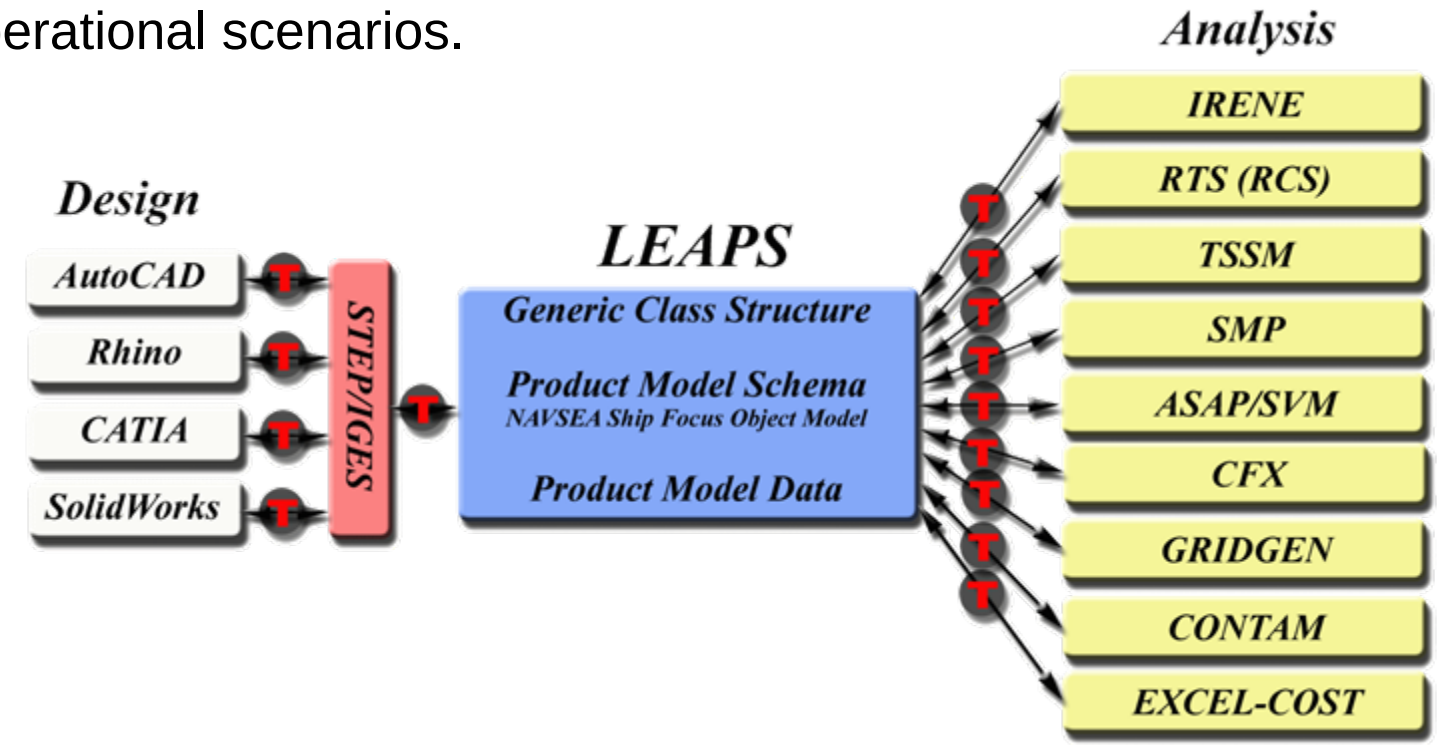
Design Activity "n" Depends on Design Variable "m" where "m" ≠ "n"

Outputs
Design Activities that produce results not used by other Design Activities

What is LEAPS?

The NAVSEA Product Modeling Environment

Leading ***E***dge ***A***rchitecture for ***P***rototyping ***S***ystems, is the product model repository used by the Naval Sea Systems Command. LEAPS is based on an extensible information meta-model. It is designed to provide product model data to support modeling and simulation tools used by Navy Ship Designers. The current focus is concept studies, analysis of alternatives, and operational scenarios.



Product Model Data

A simple definition

Product Model data is the combination of 3D geometry and non-graphic attributes to define ship objects such as a piece of equipment, deck, bulkhead, etc. Product Model data can be organized to define interim products and ultimately the entire ship.

Part & System Definition (Caterpillar 3512, Starboard Main Engine, Propulsion System)

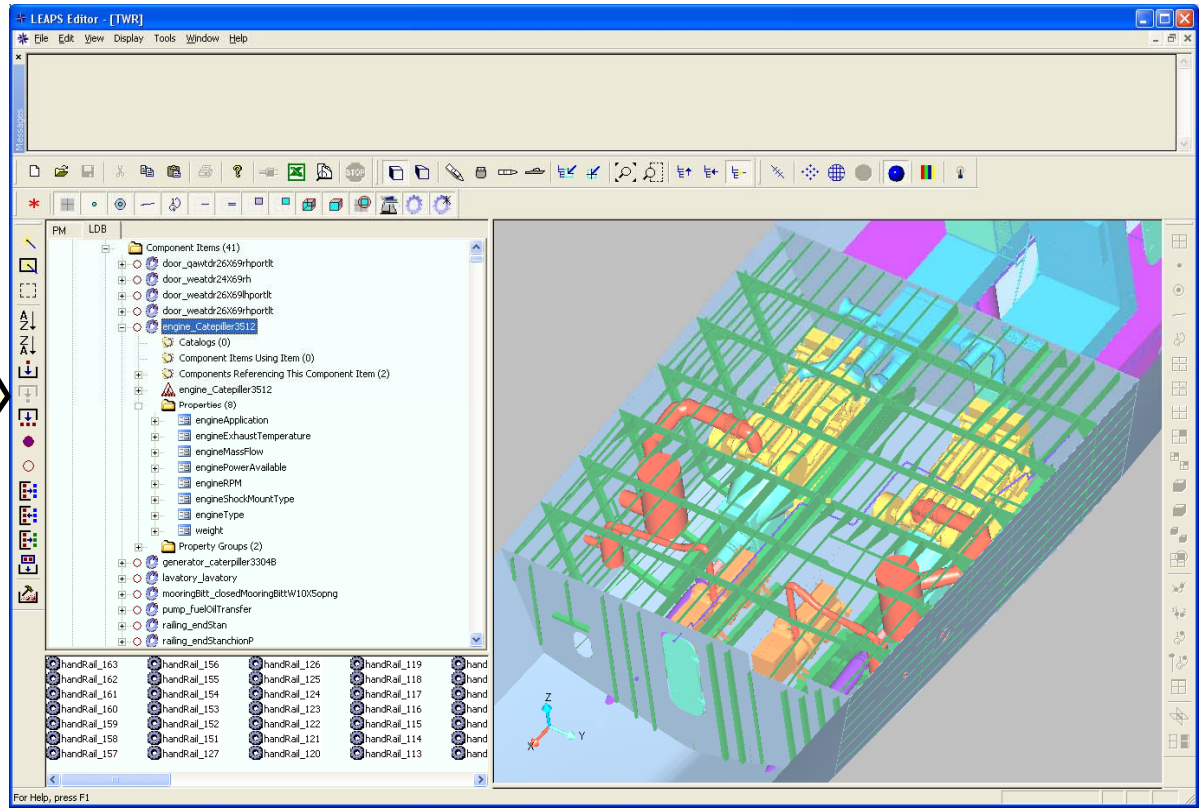
Design Definition (12 cylinder 4 stroke diesel engine)

Physical (Geometry, material connections, etc.)

Engineering Definition (1175 HP, 6464kg, 170mm bore, 190mm stroke)

Process Definition (Starting instructions, shaft alignment)

Logistics Support (FGC, SCLSIS, etc.)



Advocates anticipate substantial economies from Product-Model-based design, construction, and service-life support activities due to better integration and reduction of engineering effort to locate, verify, and transform information.

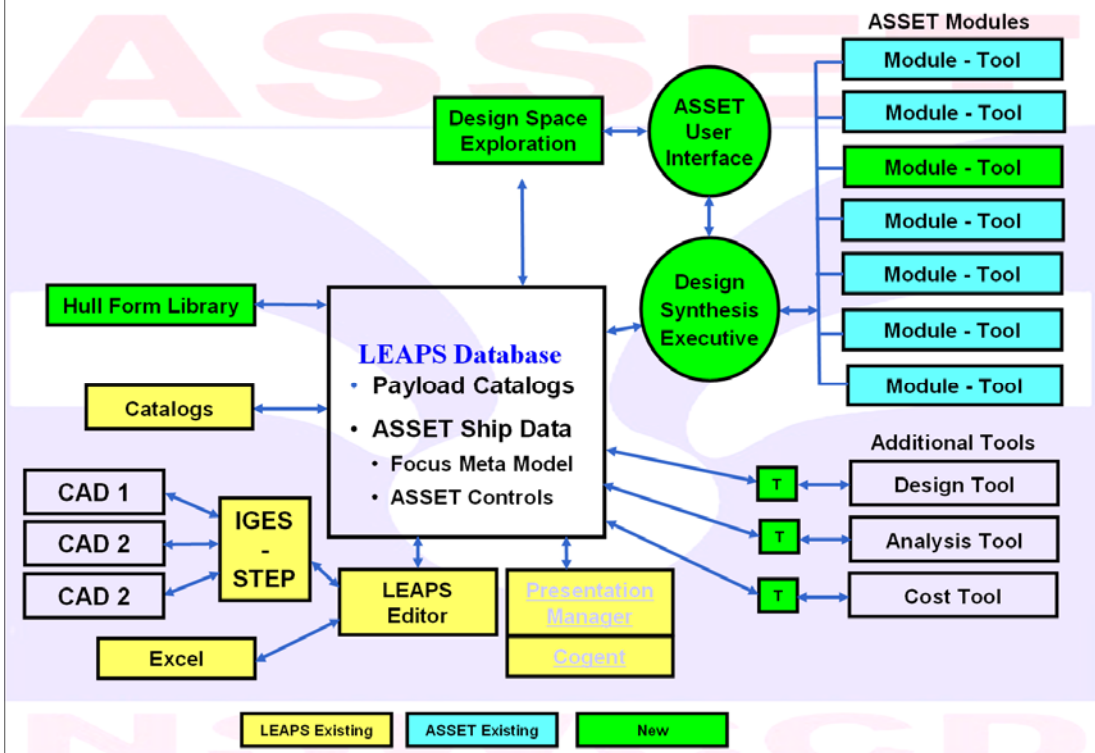
Applications migrating to LEAPS

ASSET

The primary purpose of the LEAPS Product Model database is to enable engineering analysis and M&S activities during the early phases of the ships lifecycle. The LEAPS Product Model database will interact with other M&S/Tools/Life Cycle Applications but will be external to the SPM itself.

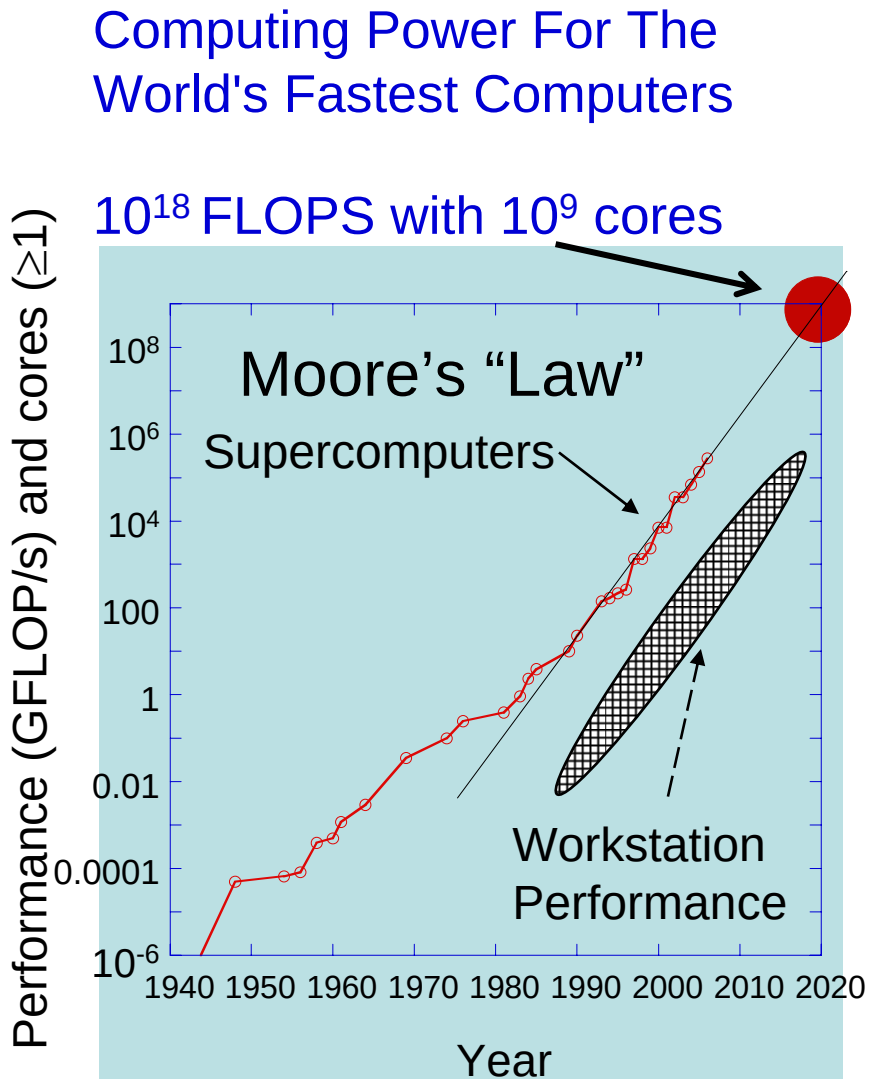
LEAPS Enables

- **Synthesis modules to work directly from a surface model.**
- **Hull surfaces can be rescaled during synthesis.**
- **Surface geometry kernel enables modeling of complex geometries.**
- **Geometry is the most important factor for accurate synthesis models.**
- **Product meta-model facilitates efficient modeling of multi-hulls.**

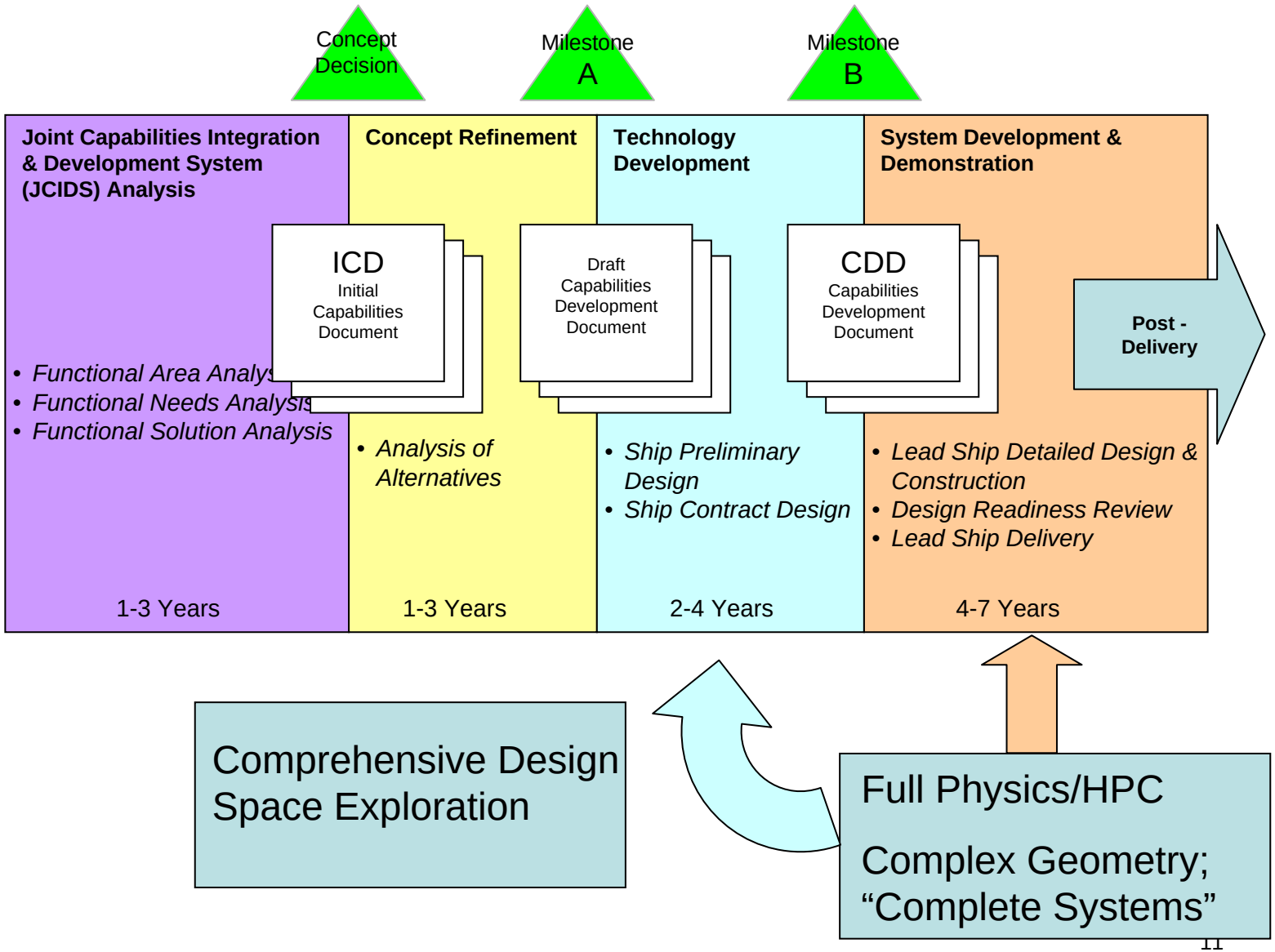


High Performance Computing and the CREATE Program

- Next generation computers (2020) will provide exciting opportunities to develop and deploy very powerful application codes:
  - Utilize accurate solution methods
  - Include all the effects we know to be important; Model a complete system
  - Complete parameter surveys in hours rather than days to weeks to months
  - Find/fix design flaws early in the process
- In ~ 10 years, workstations will be as powerful as today's supercomputers
- Need to develop codes that exploit this capability
  - Multi-Physics codes that can scale from the present (~ 10^2 cores) to the future (10^6 to 10^9 cores)



CREATE Program Goals



That's my story….